

MILITARY SPECIFICATION
INSULATION TUBING, ELECTRICAL, NONRIGID, VINYL, VERY
LOW TEMPERATURE GRADE

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 This specification covers a very low temperature grade of nonrigid tubing of polyvinyl chloride or polyvinyl chloride-acetate for use as electrical insulation.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of the specification to the extent specified herein:

SPECIFICATIONS

FEDERAL

VV-I-530 - Insulating Oil, Electrical (for Transformers, Switches, and Circuit Breakers).

MILITARY

MIL-S-3136 - Standard Test Fluids; Hydrocarbon.

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

D150 - Methods of Test for A-C Capacitance, Dielectric Constant, and Loss Characteristics of Electrical Insulating Materials.

D746 - Method of Test for Brittleness Temperature of Plastics and Elastomers by Impact.

D876 - Methods of Testing Nonrigid Polyvinyl Tubing.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pa.)

OFFICIAL CLASSIFICATION COMMITTEE

Uniform Freight Classification Rules.

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York 16, N. Y.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

3. REQUIREMENTS

3.1 Qualification.- Electrical insulation tubing furnished under this specification shall be a product which has been tested and has passed the qualification tests specified herein, and has been listed on or approved for listing on the applicable qualified products list.

3.2 Material.- The tubing shall be of polyvinyl chloride or polyvinyl chloride-acetate composition properly formulated with plasticizers, pigment, stabilizers, or other ingredients necessary to conform to this specification.

3.2.1 Changes in material.- If the manufacturer desires to change his process or the composition of his material, after qualification approval has been granted (see 6.3), he shall submit to the qualifying agency (Bureau of Ships) a statement to that effect, describing the proposed change, together with evidence to substantiate his claim that such change is suitable. Similar notification and substantiating evidence shall be submitted at any later time if a change again becomes necessary or desirable. At the discretion of the qualifying agency, test specimens may be required to prove the suitability of the proposed changes.

3.2.2 Uniformity.- All material in the same lot shall be uniform in texture, color, cross section, and finish.

3.2.3 Surface defects.- Materials shall be free from blisters, bubbles, wrinkles, and cracks, and shall be reasonably free from other small defects such as scratches and dents.

3.2.4 Colors.- Unless otherwise specified, materials shall be furnished clear transparent (uncolored). Available colors considered standard are black, white, yellow, green, blue, and red (see 6.2).

3.3 Quantitative requirements (property values).- When specimens are subjected to the tests specified in table I, the values obtained from any set of specimens for any specific property after any one conditioning procedure specified in the table shall be averaged, and this average value shall be not less than the minimum nor more than the maximum value (as applicable) specified in table I.

Table I - Quantitative requirements (property values).

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Value required
Dielectric strength ^{1/}	4.7.2	C-96/23/0	{ Volts per mil (min.)	Inches wall thickness <div> { 0.016 .020 .025 .030 .040 .050 .060 </div>	<div> 650 550 480 430 350 300 280 </div>
Dielectric strength ^{1/}	----	C-96/23/96	Percent of dry value obtained on test (min.)	All thickness	70
Dissipation factor at 1 kilocycle	4.7.3	{ C-96/23/0 C-96/23/96 }	Maximum	----	{ 0.14 0.16 }
Dielectric constant at 1 kilocycle	4.7.3	{ C-96/23/0 C-96/23/96 }	Maximum	----	{ 8.0 10.0 }

Table I - Quantitative requirements (property values) (Cont'd).

Property to be tested	Test reference	Conditioning procedure	Unit of value	Nominal dimensions	Value required
Volume resistivity	4.7.4	Di-24/23	Ohm-centimeters (min.)	Inches wall thickness ----	10^9
Tensile strength	4.7.5	C-96/23/50	P.s.i. (min.)	----	1800
Elongation	4.7.5	{ C-96/23/50 C-96/23/50	Percent (min.) Percent (max.)	---- ----	250 450
Softening temperature (penetration)	4.7.6	C-96/23/50	Degrees centi-grade (min.)	----	80
Lengthwise shrinkage	4.7.7	E-2/100	Percent (max.)	----	10
Cold brittleness	4.7.12	"As received"	Degrees centi-grade (max.)	----	-55
Cold Brittleness (aged samples)	4.7.12	E-400/100	Maximum change in degrees centi-grade from value obtained on test of "as received" samples	----	15

1/ For thickness not shown, the dielectric strength shall be that given for the nearest thickness shown.

3.4 Dimensions and tolerances.-

3.4.1 Lengths.- Unless otherwise specified in the contract or order, tubing shall be furnished on reels in lengths specified in table II (see 6.2). Tubing furnished on reels shall be wound on the reels in such a manner that the tubing will not be flattened or kinked to an extent that printing of circuit identification machine, if desired, cannot be accomplished. Minimum lengths specified shall not be exceeded by more than 10 percent.

Table II - Tubing lengths.

Nominal inside diameter	Minimum length
Inch	Feet
0.034 - 0.059	1,000
.066 - .166	500
.186 - .330	200
.360 and over	100

3.4.2 Inside diameters and wall thicknesses.- Unless otherwise specified in the contract or order, tubing shall be furnished in the standard inside diameters and wall thicknesses shown in table III, as specified (see 6.2).

Table III - Inside diameters and wall thicknesses of tubing AWG sizes.

AWG size number	Inside diameter (inches)			Wall thickness (inches)		
	Nominal	Minimum	Maximum	Minimum	Maximum	Nominal
24	0.022	0.020	0.027	0.010	0.014	0.012
22	.027	.025	.032	.010	.014	.012
20	.034	.032	.039	.013	.019	.016
19	.038	.036	.044	.013	.019	.016
18	.042	.040	.049	.013	.019	.016
17	.047	.045	.054	.013	.019	.016
16	.053	.051	.061	.013	.019	.016
15	.059	.057	.067	.013	.019	.016
14	.066	.064	.072	.013	.019	.016
13	.076	.072	.080	.013	.019	.016
12	.085	.081	.089	.013	.019	.016
11	.095	.091	.101	.013	.019	.016
10	.106	.102	.112	.013	.019	.016
9	.118	.114	.124	.017	.023	.020
8	.133	.129	.141	.017	.023	.020
7	.148	.144	.158	.017	.023	.020
6	.166	.162	.178	.017	.023	.020
5	.186	.182	.198	.017	.023	.020
4	.208	.204	.224	.017	.023	.020
3	.234	.229	.249	.017	.023	.020
2	.263	.258	.278	.017	.023	.020
1	.294	.289	.311	.017	.023	.020
0	.330	.325	.347	.017	.023	.020
5/16 inch	-----	.313	.334	.022	.028	.025
3/8 inch	-----	.375	.399	.022	.028	.025
7/16 inch	-----	.438	.462	.022	.028	.025
1/2 inch	-----	.500	.524	.022	.028	.025
5/8 inch	-----	.625	.655	.025	.035	.030
3/4 inch	-----	.750	.786	.030	.040	.035
7/8 inch	-----	.875	.911	.030	.040	.035
1 inch	-----	1.000	1.036	.030	.040	.035
1-1/4 inches	-----	1.250	1.290	.035	.045	.040
1-1/2 inches	-----	1.500	1.550	.039	.051	.045
1-3/4 inches	-----	1.750	1.812	.047	.063	.055
2 inches	-----	2.000	2.070	.050	.070	.060

3.5 Qualitative requirements.-

3.5.1 Oil resistance - flexibility.- At the completion of the test specified in 4.7.8, oil shall not have penetrated the tubing, and the tubing shall not have developed cracks or increased in dimensions at any point by more than 10 percent.

3.5.2 Flame resistance.- The average duration of burning shall not exceed 15 seconds, and the paper indicator shall show no evidence of being affected when tested as specified in 4.7.9.

3.5.3 Corrosive effect.- Copper shall not be corroded or otherwise adversely affected by contact with the material. The resistance of the copper wire shall not increase by more than 2 percent (see 4.7.10).

3.5.4 Fungus resistance.- The material shall be tested for fungus resistance as specified in 4.7.11. The material shall not support fungus growth and shall be fungus-resistant. The material shall be considered fungus-resistant if at least two of three specimens are rated 0 to 1.

3.6 Chemical analysis.- The composition of material is determined by chemical analysis on material offered under a contract or order shall not differ significantly from the composition of the samples submitted for qualification approval (see 4.7.13).

3.7 Storage stability. - At the end of 12 months storage specified in 4.7.14 there shall be no evidence of spewing (oily or sticky exudation) on the inner and outer surfaces of the tubing. At the end of the 12 months storage the material shall conform to the fungus resistance requirements of 3.5.4.

3.8 Workmanship. - The material shall be manufactured and processed in a careful and workmanlike manner, in accordance with good practice.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification; where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection. - The inspection of tubing shall be classified as follows:

- (a) Qualification tests.
- (b) Quality conformance inspection.

4.3 Qualification tests. - Qualification tests shall be conducted at a laboratory satisfactory to the Bureau of Ships. Qualification tests shall consist of the tests specified in table IV. Application for Qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 6.3 and 6.4).

Table IV - Qualification tests.

Test	Requirement reference	Test reference	Minimum number of tests for each condition (see 4.6)		
			Number 18 AWG	Number 12 AWG	Number 6 AWG
Visual and dimensional examination	3.2, 3.4, and 3.8	4.5.1 and 4.7.1	10	10	10
Electrical properties:					
Dielectric strength	3.3	4.7.2	10	10	10
Dissipation factor	3.3	4.7.3	--	--	3
Dielectric constant	3.3	4.7.3	--	--	3
Volume resistivity	3.3	4.7.4	3	3	3
Mechanical properties:					
Tensile strength	3.3	4.7.5	5	5	5
Elongation	3.3	4.7.5	5	5	5
Thermal properties:					
Softening temperature (penetration)	3.3	4.7.6	5	5	5
Lengthwise shrinkage	3.3	4.7.7	3	3	3
Cold brittleness	3.3	4.7.12	As specified in 4.7.12.3.1	As specified in 4.7.12.3.1	As specified in 4.7.12.3.1
Cold brittleness (aged samples)	3.3	4.7.12	As specified in 4.7.12.3.1	As specified in 4.7.12.3.1	As specified in 4.7.12.3.1
Flame resistance	3.5.2	4.7.9	5	5	5
Miscellaneous:					
Oil resistance-flexibility	3.5.1	4.7.8	1	1	1
Corrosive effect	3.5.3	4.7.10	--	--	2
Fungus resistance	3.5.4	4.7.11	3	--	3
Chemical analysis	3.6	4.7.13	1	1	1
Storage stability	3.7	4.7.14	3	--	3

4.3.1 Samples for qualification tests.- The sizes and quantities of tubing for qualification inspection shall be as shown in table V.

Table V - Sizes and quantities of tubing for qualification tests.

AWG size number	Inside diameter		Nominal wall thickness	Amount
	Minimum	Maximum		
	Inch	Inch	Inch	Feet
18	0.040	0.049	0.016	200
12	.081	.091	.016	200
6	.162	.178	.020	200

4.4 Sampling for quality conformance inspection.-

4.4.1 Lot.- For purpose of sampling, a lot shall consist of all tubing of the same size (see table III) produced under essentially the same conditions and offered for delivery at the same time. The lot size shall be the number of units of product.

4.4.1.1 Unit of product.- The unit of product shall be taken as 100 feet of tubing.

4.4.2 Samples of tubing shall be selected from each lot in accordance with MIL-STD-105. The acceptable quality level (AQL) shall be 2.5 percent defective major and 4 percent defective minor for examination specified in 4.5.1.

4.4.3 Sampling for quality conformance tests.- Sampling for quality conformance tests from each lot shall be in accordance with 4.5.2.

4.5 Quality conformance inspection.-

4.5.1 Examination.- Each sample selected in accordance with 4.4.2 shall be visually and dimensionally examined to verify conformance with the requirements in 3.2, 3.4, and 3.8. Any reel having one or more defects shall not be offered for delivery. If the number of defective samples exceeds the acceptance number for the appropriate sampling plan of MIL-STD-105 at AQL 2.5 percent major and 4 percent minor, this shall be cause for rejection of the lot represented by the samples.

4.5.2 Quality conformance tests.- Quality conformance tests shall consist of those specified in table VI (samples for group 1 tests) and shall be selected from each lot in accordance with the table for small sampling inspection of MIL-STD-105. The AQL shall be 6.5 percent defective, level 7 normal and tightened and level 5 for reduced, using procedure R-1. Two samples shall be selected from each 500 units or fraction thereof and shall be subjected to the group 2 test. Failure of a sample for any group 2 test shall result in rejection of the lot.

4.6 Conditioning.- The tubing shall be conditioned before being tested as specified in table I.

4.6.1 Equipment.- Conditioning chambers and baths shall be such as to maintain the specified temperature plus or minus 2°C. and the specified relative humidity plus or minus 2 percent.

4.6.2 Designation.- Conditioning procedures shall be designated as follows:

- (a) A capital letter indicating the general condition of the specimen; that is, humidity, immersion, and temperature conditioning.
- (b) A number indicating in hours the duration of the conditioning.
- (c) A number indicating in degree centigrade the conditioning temperature.
- (d) A number indicating relative humidity whenever relative humidity is controlled. (Relative humidity obtained over calcium chloride shall be taken as zero.)

The numbers shall be separated from each other by slant marks, and from the capital letter by a dash.

Table VI - Quality conformance tests.

Test	Requirement reference	Test reference	Conditioning prior to test (see 4.6)	Minimum number of tests per sample
<u>Group 1 - all samples</u>				
Dielectric strength	3.3	4.7.2	{ C-96/23/0 C-96/23/96	10 10
Tensile strength and elongation	3.3	4.7.5	C-96/23/50	2
Lengthwise shrinkage	3.3	4.7.7	E-2/100	1
<u>Group 2 - two samples</u>				
Softening temperature (penetration)	3.3	4.7.6	C-96/23/50	5
Cold brittleness	3.3	4.7.12	"As received"	As specified in 4.7.12.3.2
Chemical analysis	3.6	4.7.13	-----	One composite sample

4.6.3 Nomenclature. - The following letters shall be used to indicate the respective general conditioning:

Condition C - The specimens shall be conditioned for the time and at the temperature and relative humidity specified.

Examples:

C-96/23/0 - 96 hours, 23°C., 0 percent relative humidity (desiccation over calcium chloride).

C-96/23/50 - 96 hours, 23°C., 50 percent relative humidity.

C-96/23/96 - 96 hours, 23°C., 96 percent relative humidity.

Condition D_t - The specimens shall be immersed in 1 percent salt water for the time and at the temperature specified.

Example:

D_t-24/23 - 24 hours, 23°C., in 1 percent salt water.

Condition E - The specimens shall be conditioned for the time and at the temperature specified.

Example:

E-2/100 - 2 hours, 100°C.

E-400/100 - 400 hours, 100°C.

E-200/50 - 200 hours, 50°C.

4.7 Procedures for examination and tests. - The procedures for examination and tests shall be as specified in 4.7.1 to 4.7.14, inclusive. Unless otherwise specified herein, all methods shall be conducted under room conditions (23 ± 2°C., 50 ± 2 percent relative humidity).

4.7.1 Inside and outside diameters and wall thickness. - The inside diameter, the outside diameter, and wall thickness of the tubing shall be determined in accordance with the method specified in ASTM D876. The inside diameter, however, may be determined by measuring the diameter of the mandrel adjacent to the edge of the tubing specimen by use of a chisel point micrometer. The inside diameter, the outside diameter, and wall thickness shall be measured at a minimum of 10 representative points along the length of the sample. At each point three measurements approximately 120 degrees apart shall be made of the outside diameter. The average inside diameter and outside diameter shall be reported, and the average wall thickness shall be reported as one half the difference of the two averages.

4.7.2 Dielectric strength. -

4.7.2.1 Test equipment. - The test equipment shall consist of a high voltage transformer rated at not less than 2 kilovolt-amperes and the necessary auxiliary equipment for applying, controlling, and measuring the test voltage. The power supply shall consist of an alternating-current source having as nearly a true sine wave as possible at a frequency not exceeding 100 cycles per second.

4.7.2.2 Voltage control. - The high-tension voltage taken from the secondary of the testing transformer shall be capable of being raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation with an induction regulator, or with a variable ratio auto-transformer. Any method of controlling the voltage which does not distort the wave more than 10 percent from a sinusoidal shape is satisfactory.

4.7.2.3 Voltage measurement. - The voltage shall be measured by any method which gives root-mean-square values, preferably by means of a voltmeter connected to a tertiary coil in the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low tension side of the transformer is satisfactory if the ratio of the transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

4.7.2.4 Test electrodes. - The test electrodes shall consist of a solid conductor which fits the inside of the tubing closely without stretching the tubing, and tightly wrapped 1-inch strip of metal foil on the outside. In the case of flexible tubing of 0.315 inch inside diameter and larger, the tubing may be cut along its axis, flattened, and tested with electrode bars 4 inches long and 1/4 inch wide, rounded at the ends, and with all edges in contact with the sample rounded to a radius of 1/32 inch. The total weight on the sample shall be approximately 1/2 pound.

4.7.2.5 Specimens. - Pieces 12 inches long shall be cut. Each of the pieces shall be cut in half cross-wise to obtain the test specimens. One half of each piece shall be tested after condition C-96/23/0. The other half of each piece shall be tested after condition C-96/23/96.

4.7.2.6 Procedure. -

4.7.2.6.1 Tests shall be made at 23°C, with the specimen immersed in temperature-controlled transformer oil conforming to VV-I-530. This oil shall be changed frequently to prevent excessive deterioration. The test electrodes shall be kept clean and polished. They shall be self-aligning, and shall be placed exactly opposite one another, with the specimen in a horizontal plane between them.

4.7.2.6.2 Starting at zero, the voltage shall be increased uniformly to a breakdown, at a rate of 500 volts per second. The average dielectric breakdown of the material shall be expressed in volts. The dielectric strength shall be computed by dividing the average dielectric breakdown by the average thickness, and shall be reported in volts per mil. The average thickness shall be determined as specified in 4.7.1, and hence will be the same in calculation of dielectric strength for both conditions C-96/23/0 and C-96/23/96.

4.7.3 Dissipation factor and dielectric constant (at 1 kilocycle)^{1/}. -

4.7.3.1 Test equipment. - The test equipment shall be a suitable bridge or bridges. The bridge or bridges used shall be suitable for the measurement of dissipation factor and dielectric constant at the specified frequency. Five bridge arrangements which have been found satisfactory for the purpose intended are the "Conjugate Schering Bridge," the "High Voltage Schering Bridge," the "Parallel Resistance Bridge," the "Series Resistance Bridge," and the "Transformer Bridge." It is not intended, however, that the use of other types of bridges of equal precision and convenience be excluded.

4.7.3.2 Sensitivity. - The method used shall have an accuracy of determination of dielectric constant of plus or minus 5 percent, and an accuracy of determination of dissipation factor of plus or minus 5 percent of 0.0002, whichever is greater.

4.7.3.3 Specimens. - Larger sizes of tubing (1 inch or greater) may be slit along the axis of the tubing and flattened to obtain the sheet specimen. Small tubing shall be tested in full section.

4.7.3.4 Electrodes. - The inner electrode shall be a snug-fitting metal mandrel and the outer electrode shall be a metal foil 3 inches wide, tightly wrapped around the tubing, using a thin film of petrolatum to prevent air entrapment and to provide adhesion.

^{1/}For a complete discussion of the theory, apparatus electrodes, procedure, and calculation, refer to ASTM D150.

4.7.4 Volume resistivity.-

4.7.4.1 Apparatus.- The apparatus shall consist of a source of direct-current potential of 100 to 200 volts, a galvanometer with suitable shunts having a minimum sensitivity of 0.0005 microampere per millimeter at one meter-scale distance, a calibrated resistance, reversing switches, and keys. Any other apparatus may be used provided the same accuracy is obtained and the same voltage is applied. In addition, there shall be a container for water large enough to accommodate a specimen of tubing bent into a U-shape and a support for the two branches of the U-shaped tubing.

4.7.4.2 Specimens.- The test specimens shall be cut sufficiently long so that satisfactory reading may be obtained on the galvanometer. The minimum length shall be 2 feet.

4.7.4.3 Procedure.- The specimen shall be shaped without kinking into a U-form and immersed in water, at $23^{\circ} \pm 2^{\circ}\text{C}$, containing 1 percent sodium chloride. Not less than 1 foot of the specimen shall be submerged. To prevent leakage of electric current, the ends of the specimen shall protrude 6 inches above, and approximately perpendicular to the surface of the water. The specimen shall be filled immediately with the same salt water, and, as a precaution against air bubbles and discontinuity of the water phase, a fine wire shall be inserted throughout the length of the specimen. The salt water in the tubing shall serve as an inner electrode, and its surface shall be above the surface of the salt water in the container. The salt water in the container shall serve as an outer electrode. The specimen shall remain in the water for 24 hours. At the end of this time the reading shall be taken one minute after application of voltage.

4.7.4.4 Calculation.- Voltage resistivity, r , in ohm-centimeters, shall be calculated as follows:

$$r = \frac{RL \times 10^6}{0.3663 \times \log \frac{(D)}{d}}$$

Where:

R = volume resistance in megohms.
 L = length of specimen in centimeters.
 D = outside diameter.
 d = inside diameter.

Note.- Log is to the base 10.

4.7.5 Tensile strength and elongation.-

4.7.5.1 Apparatus.- Tensile strength and elongation shall be determined on an approved pendulum-type or constant rate of elongation testing machine. The machine shall preferably be power-driven.

4.7.5.2 Specimens.- Specimens of each size of tubing shall be tested after being subjected to Condition C-96/23/50. Tubing of 0.315 inch inside diameter and larger shall be tested by using 1/2-inch, dumbbell, die-cut specimens. Tubing in smaller size inside diameters shall be tested in full tubing section.

4.7.5.3 Procedure.- Two-inch bench marks shall be used on all specimens. The test specimens shall be placed in the testing machine and stretched until they break. The rate of separation of the jaws of the machine shall be 12 plus or minus 1/2 inch per minute. A scale shall be used to measure the elongation at the instant of rupture. The tensile strength shall be reported in pounds per square inch.

4.7.6 Softening temperature (penetration).-

4.7.6.1 Apparatus.- The apparatus shall consist of an oven capable of raising the temperature of a stainless steel plate 1/8 by 1-1/4 by 4 inches, at the rate of 1°C . every 2 minutes; a 1/16-inch magnetized steel rod, recessed at one end to hold a 1/16-inch ball, in contact with and equipped to exert a pressure of 1,000 grams vertically down against the stainless steel plate, lying in a horizontal plane; an electrical circuit with a 110-volt source of electricity; a 110-volt glow lamp; and a suitable means of measuring the temperature of the steel plate as near the point of test application as practicable. The use of a thermocouple to measure this temperature is suggested. Equipment as shown on figure 1 is recommended. The light C-clamp, containing the steel rod, counterbalance, and weight, shall be mounted on a bearing capable of giving the unit the necessary freedom of clockwise motion. With no load on the lower leg of the C-clamp, the counterbalance shall be adjusted to neutralize the pressure of the ball against the steel plate.

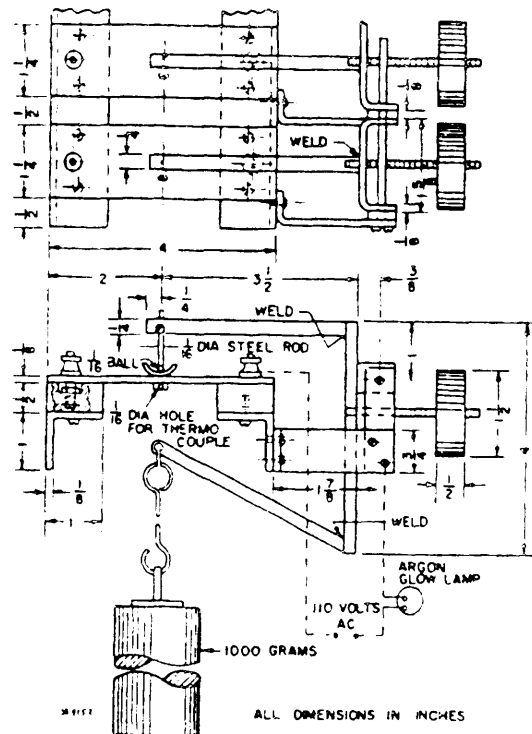


Figure 1 - Equipment for softening-temperature (penetration) test.

4.7.6.2 Specimens.- One-inch long specimens shall be cut from the sample and prepared for test. This may be accomplished by opening one side of the tubing along the longitudinal axis.

4.7.6.3 Procedure.- With no load on the rod, each specimen shall be inserted between the steel ball and steel plate with the outside surface of the tubing facing the plate. The electrical circuit shall be connected in such a way that when the steel ball comes in contact with the plate, the lamp contained outside the oven will light. The specimen in the oven at room temperature shall then be put under a compression load of 1,000 grams. The temperature of the steel plate shall be uniformly raised at the rate of 1°C . every 2 minutes until failure of the specimen, which is indicated by the lighting of the lamp. The temperature at failure shall then be recorded as the softening temperature (penetration).

4.7.7 Lengthwise shrinkage.-

4.7.7.1 Specimens.- Full section tubing in lengths of 6 inches with 5 inches between bench marks shall be tested.

4.7.7.2 Procedure.- The specimens shall be supported by insertion of a solid conductor having a diameter slightly less than the inside diameter of the tubing, and well coated with talc to prevent bonding. The specimens so supported shall be held horizontally in an oven and subjected to condition E-2/100. The specimens shall then be removed and cooled to room temperature (23°C .). The length of the material shall be measured before and after heating and the percent shrinkage calculated from these values.

4.7.8 Oil resistance - flexibility.-

4.7.8.1 Specimens.- The tubing specimens shall be 18 inches long.

4.7.8.2 Apparatus.- Tests on the tubing shall be made in a closed container approximately 6 inches deep, filled with high-swelling oil conforming to type VI of MIL-S-3136 to a line 2 inches below the cover. The tubing specimens shall be bent in the shape of a U around a diameter of approximately 4 inches, with the ends protruding through the cover and the bottom of the U located 3 inches below the surface of the oil.

The specimen then has a section immersed in oil, a section in oil vapor, and a section above the cover subjected to oven temperature only.

4.7.8.3 Procedure.- The entire equipment shall be subjected to condition E-200/50. The specimens shall be removed and tested to determine compliance with 3.5.1.

4.7.9 Flame resistance.-

4.7.9.1 Apparatus.-

4.7.9.1.1 Sheet-metal enclosure.- A three-wall sheet-metal enclosure, 12 inches wide by 14 inches long by 29 inches high, shall be used. The walls facing each other shall support two parallel horizontal steel rods; these rods of 1/4 inch diameter shall be separated 16 to 21 inches as required, with the lower rod closer to the back wall, and shall be located so that they define a plane which shall be set at an angle of 70 degrees to the horizontal.

4.7.9.1.2 Bare steel wire.- A length of bare steel wire, approximately 0.029 inch in diameter for all sizes of specimens, shall be attached at one of its ends to the center of the upper rod. The other end of the wire shall pass over the center of the lower rod and shall have a 1-pound weight attached to maintain the wire in a straight line across the two rods.

4.7.9.1.3 Tirrill burner.- A tirrill burner having a nominal bore of 3/8 inch and a length of approximately 4 inches above the primary inlets with an attached pilot light shall be used.

4.7.9.1.4 Gas supply.- A supply of ordinary illuminating gas at normal pressure shall be available.

4.7.9.1.5 Timer.- A timer measuring seconds shall be used.

4.7.9.1.6 Flame indicators.- Strips of gummed paper shall be used as flame indicators.

4.7.9.2 Specimens.- For inside diameters of 7/8 inch and less, specimens 17 inches long shall be cut from the sample. For inside diameters of more than 7/8 inch, specimens 22 inches long shall be cut from the sample.

4.7.9.3 Procedure.-

4.7.9.3.1 For round tubing.-

4.7.9.3.1.1 Preparation.- The test shall be made in a room or cabinet free from drafts of air. The specimen shall be drawn onto the wire. The covered wire shall be fastened into position, with its length adjusted so that the weight hangs free, maintaining tension and supporting the specimen in a straight line at an angle of 70 degrees with the horizontal. One end of the specimen shall be near the lower rod, and the other end shall be drawn to the upper rod and clamped so that the specimen is closed, in order to prevent a draft through the tube. The paper indicator shall be applied to the upper end of the specimen, in such a position that, for tubing 7/8 inch and less in inside diameter, the lower edge is 10 inches away from the point at which the inner cone of the test flame is to be applied. For tubing more than 7/8 inch in inside diameter, the lower edge of the paper indicator shall be 15 inches away from the point at which the inner cone of the test flame is to be applied. The indicator shall be wrapped and pasted around the specimen.

4.7.9.3.1.2 Application of flame.- The height of the flame with the burner in a vertical position shall be adjusted to 5 inches with an inner cone of 1-1/2 inches high. The burner, with only the pilot lighted, on a base at an angle of 25 degrees with the horizontal, shall be placed in such a position under the specimen that the axis of the burner makes an angle of 45 degrees with the specimen, and there is a distance of 1-1/2 inches between the tip of the stem and the surface of the specimen, along the axis of the burner stem. The valve controlling the gas supply shall be opened, and the flame applied to the specimen for 15 seconds.

4.7.9.3.2 For flat tubing.-

4.7.9.3.2.1 Preparation.- The wire shall support the specimen by one of the two small curvatures found in flat tubing. The flats of the tubing shall be directed vertically downward. The distance of 1-1/2 inches from burner to specimen shall be between the tip of the stem and the surface of the narrow side of the flat specimen.

4.7.9.3.2.2 Application of flame.- The valve controlling the gas supply to the burner shall be opened, and the flame shall be applied to the narrow side of the specimen for a period of 15 seconds. The duration of burning shall be determined immediately after removal of the flame.

4.7.9.3.3 Calculation.- The length of specimen burned shall be determined by subtracting the length of the unburned portion from the original length of the test specimen. The unburned portion is the distance from the lower edge of the indicator paper to the first obvious defect caused by the flame.

4.7.10 Corrosive effect.- Specimens of tubing of 0.315-inch inside diameter, and larger, shall be slit lengthwise to form tape 3/8-inch wide. The tape shall be butt-wrapped full length and return on a 6-inch piece of 0.162-inch diameter (AWG No. 6) copper wire. Tubing of less than 0.315 inch inside diameter shall be tested by inserting the proper size wire into a 6-inch length of tubing. A 30-inch length of 0.006-inch diameter, bare copper wire in a bifilar winding shall then be wrapped over the prepared specimens. If wrapped in the proper manner, the bifilar winding will not cross the edges of the specimen strip at any point. The ends of the wire shall be welded to heavy leads of 0.040-inch diameter (AWG No. 18) copper wire, and the sample placed in a test tube with the leads extending through a cork. A small amount of distilled water shall be placed in the test tube to maintain a high relative humidity, and the cork shall be coated to produce a vapor-tight seal. The entire equipment shall be placed in an oven maintained at 70°C. The resistance of the 0.006-inch diameter copper wire shall be measured when the temperature of the specimen reaches 70°C and at 24-hour intervals for 720 hours. At the end of this period, specimens shall be examined for visual evidence of corrosion on the 0.006-inch diameter wire, and the increase in resistance of the wire shall be reported in percent. Percentage change in resistance versus time shall be plotted to show corrosion characteristics of the material.

4.7.11 Fungus resistance.-

4.7.11.1 Test fungi.- The following test fungi (see 6.4) shall be used:

	American type culture collection number
Aspergillus niger	9642
Aspergillus flavus	9643
Penicillium luteum	9644
Trichoderma T-1	9645

Cultures of these fungi shall be maintained separately on an appropriate medium, such as potato-dextrose agar. The stock cultures may be kept for not more than 4 months in a refrigerator, at approximately 3° to 10°C. Subcultures incubated at 28° to 30°C., for 7 to 20 days, shall be used in preparing the spore suspension.

4.7.11.2 Spore suspension.- A separate sterile 10 milliliter (ml.) portion, of distilled water or of a solution containing per liter 0.05 gram of a nontoxic wetting agent such as dioctyl sodium sulfosuccinate, shall be poured into one subculture of each of the four fungi and agitated to dislodge the spores. The resulting separate spore suspensions shall be mixed to provide a composite spore suspension for use in the test. The spore suspension shall be prepared freshly upon the day of the test.

4.7.11.3 Controls.- The viability of the inoculum shall be checked with each composite spore suspension, upon each day when it is used for inoculation. Three agar slants, of an appropriate medium such as potato-dextrose agar, shall serve as controls. A drop of the composite spore suspension shall be deposited with aseptic precautions at the top of each slant. The controls shall then be incubated with the test specimens. The spore suspension shall be considered satisfactory provided all three controls are covered with fungus growth at the end of the incubation period of 21 days.

4.7.11.4 Specimens.- Specimens representative of large size tubing shall be 1-1/2-inch squares cut from the tubing; specimens of small diameter tubing shall be 1-1/2 inch lengths cut from the tubing.

4.7.11.5 Procedure.- The test medium shall contain 20 grams of agar and 1,000 ml. of distilled water. Each test specimen shall be placed in the center of a petri dish containing approximately 25 ml. of solidified test medium. The specimens shall then be sprayed with the mixed spore suspension (see 4.7.11.2). The inoculated specimens shall be incubated for 21 days at 28° to 30°C.

4.7.11.6 Evaluation of results.- At the end of the 21-day incubation period, each specimen shall be examined and rated as follows:

<u>Observed fungus growth on the specimen</u>	<u>Rating</u>
No growth	0
Traces of growth ^{1/}	1
Partial coverage, slight to moderate growth	2
Moderate growth, considerable coverage	3
Abundant growth, complete coverage	4

^{1/}Traces of growth may be defined as scattered, sparse fungus growth such as might develop from an unusual mass of spores in the original inoculum, or upon an occasional extraneous bit of debris. (Continuous cobwebby growth, extending over the entire surface of the specimen, even though not necessarily obscuring the specimen, should be rated as 2.)

4.7.12 Cold brittleness.

4.7.12.1 Specimens.- For tubing size number 7 and larger inside diameter test specimens 1/4 inch in width and 1-1/2 inches in length shall be cut from the tubing. This shall be accomplished by cutting a 1/4 inch strip along a longitudinal axis of the sample. For tubing size number 8 and smaller inside diameter, test specimens in full section 1-1/2 inches in length shall be cut from the tubing. In qualification tests, two sets of specimens shall be tested; one set of specimens shall be "as received," the other after being subjected to condition E-400/100 (aged samples). In acceptance tests only specimens "as received" shall be tested.

4.7.12.2 Apparatus.- The apparatus shall be in accordance with ASTM D746 except that the brittleness testing machine shall be motor driven. The dimensional requirements between specimen clamp and striking arm are shown on figure 2.

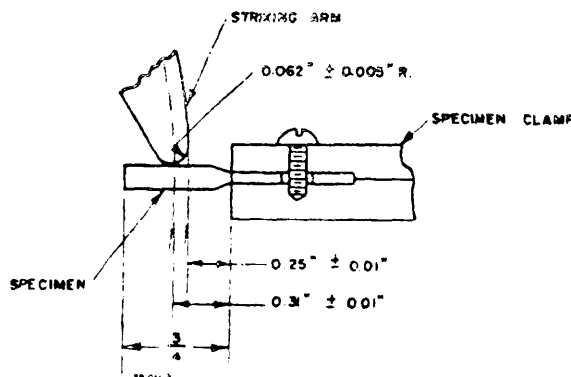


Figure 2 - Specimen clamp and striking arm.

4.7.12.3 Procedure.

4.7.12.3.1 For qualification tests.- Ten specimens shall be tested at each temperature starting at the estimated brittle temperature in accordance with standard method of ASTM D746. Two-degree C. temperature intervals shall be used. The specimens shall be immersed in the coolant at the temperature for 3.0 ± 0.5 minutes and the blow delivered. Failure is defined as the division of a specimen into two or more completely separated pieces or as any crack in the specimen which is visible to the unaided eye. Where a specimen has not completely separated, it should be bent to an angle of 90 degrees in the same direction as the bend caused

by the impact. It should be examined for cracks at the bend. The 50-percent brittle temperature shall be calculated in accordance with ASTM D746 for each set of specimens.

4.7.12.3.2 For quality conformance tests.- Eighteen specimens, "as received" shall be selected from each size submitted. When there is more than one sample of any size, the 18 specimens shall be equally distributed between these samples. The specimens shall be immersed in the coolant at $-55^{\circ}\text{C.} \pm 0.5^{\circ}\text{C.}$ for 3.0 plus or minus 0.5 minutes and the blow delivered. Failure is defined as in 4.7.12.3.1. In acceptance tests not more than 9 of the 18 specimens shall fail.

4.7.13 Chemical analysis.- A chemical analysis shall be performed to determine the relative proportions and the general type of the basic resin, the plasticizing agent, and the pigments or loading materials, comprising the finished compound. Specific gravity refractive index, where practicable, and solubility in organic solvents shall also be determined. (Benzene, petroleum ether, acetone, and carbon tetrachloride shall be considered as representing aromatic, aliphatic, oxygenated and chlorinated solvents, respectively.)

4.7.14 Storage stability.- Specimens approximately 8 inches long of each size of tubing shall be examined carefully for surface condition and then placed in a 1-quart clamp-top mason jar. The top of the jar shall then be clamped on without the rubber ring in place (so that the jar will not be sealed). The jars shall then be stored in a dark cabinet at 23°C. and 50 percent relative humidity for a period of 12 months. Specimens shall be examined monthly for evidence of spewing (oily or sticky exudation). At the end of the 12-month period, the tubing shall be tested for fungus resistance as specified in 4.7.11.

4.8 Inspection of packaging and packing.- Sample packages shall be selected and inspected to verify conformance to the requirements of section 5 herein.

5. PREPARATION FOR DELIVERY

5.1 Domestic shipment and early material use.

5.1.1 Insulation tubing.

5.1.1.1 Packaging.- Packaging shall be sufficient to afford adequate protection against deterioration and physical damage during shipment from the supply source to the using activity and until early use and may conform to the suppliers commercial practice when such meets these requirements.

5.1.1.2 Packing.- Packing shall be accomplished in a manner which will insure acceptance by common carrier and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early use. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation and may conform to the suppliers commercial practice when such meets these requirements.

5.1.1.3 Marking.- Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, Federal stock number or manufacturer's part number, contract or order number, contractor's name, and destination.

5.2 Domestic shipment and storage or overseas shipment.- The requirements and levels of preservation, packaging, packing, and marking for shipment shall be specified by the procuring activity (see 6.2).

(5.2.1 The following provides various levels of protection during domestic shipment and storage or overseas shipment, which may be required when procurement is made by a Government activity (see 6.2):

5.2.1.1 Packaging.

5.2.1.1.1 Level A.- Reels of tubing shall be individually wrapped in not less than 30-pound basic weight kraft paper, waxed on one side only (waxed side out), and securely sealed with 2-inch width tape. The tape shall be applied in such lengths that it will entirely encircle the roll and lap on itself at least 2 inches. Reels of tubing shall be further packaged in fiberboard boxes conforming to PPP-B-636.

5.2.1.2 Packing.

5.2.1.2.1 Level A.- Reels of tubing shall be packed in overseas type, wood-cleated fiberboard, nailed wood, wirebound wood, fiber, wood-cleated veneer paper overlaid, or wood-cleated plywood boxes conforming to PPP-B-591, PPP-B-621, PPP-B-585 (class 3), PPP-B-636 (class 2), PPP-B-576 (class 2), or PPP-B-601, respectively, at the option of the contractor. Shipping containers shall have case liners conforming to MIL-L-10547, and shall be closed and sealed in accordance with the appendix thereto. Case liners for boxes conforming to PPP-B-636 may be omitted provided all center and edge seams and manufacturer's joint of the boxes are waterproofed in accordance with the appendix to PPP-B-636. Boxes shall be closed, strapped, or banded in accordance with the applicable box specification or appendix thereto. The gross weight of wood or wood-cleated boxes shall not exceed 200 pounds.

5.2.1.2.2 Level B.- Reels of tubing shall be packed in domestic type wood-cleated fiberboard, nailed wood, wirebound wood, cleated plywood, or wood-cleated veneer paper overlaid boxes or class 1 fiber boxes conforming to PPP-B-591, PPP-B-621, PPP-B-585, PPP-B-601, PPP-B-576 (class 1), or PPP-B-636, respectively, at the option of the contractor. Box closures shall be as specified in the applicable box specification or appendix thereto. The gross weight of wood or wood-cleated boxes shall not exceed 200 pounds.

5.2.1.3 Marking.- In addition to any special marking required, interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129.)

6. NOTES

6.1 Intended use.- The tubing covered by this specification is intended for applications involving very low temperatures where a flexible, high elongation, elastic material with good electrical properties is required.

6.2 Ordering data.- Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Color, if required (see 3.2.4)
- (c) Dimensions required (see 3.4)
 - Number of feet required.
 - Number of feet in single reel (see 3.4.1).
 - AWG size number (see 3.4.2).
 - Nominal wall thickness (see 3.4.3).
- (d) Packaging, packing, or marking requirements other than those required by 5.1 (See 5.2).

6.3 With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set for opening of bids, been tested and approved for inclusion in Qualified Products List QPL-22076 whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification, in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is the Bureau of Ships, Department of the Navy, Washington 25, D. C., and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification" (see 6.4).

6.4 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Supply Depot, 5801 Tabor Avenue Philadelphia 20, Pennsylvania.

6.5 Sources of stock fungus cultures.- The test fungi designated for use in tests may be obtained from the American Type Culture Collection, 2029 M Street, N. W., Washington 6, D. C.

Custodians:
 Army - EL
 Navy - Ships
 Air Force - SGEES

Preparing activity:
 Navy - Ships
 (Project 5970-0111)